BALLANTINE LABORATORIES - BOONTON - N. J.

INSTRUCTIONS FOR THE MODEL 316 INFRASONIC PEAK-TO-PEAK VOLTMETER

BALLANTINE ELECTRONIC INSTRUMENTS

INSTRUCTIONS FOR THE
MODEL 316
INFRASONIC
PEAK-TO-PEAK VOLTMETER

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1. GENERAL DESCRIPTION

The Ballantine Model 316 Infrasonic Peak-to-Peak Voltmeter is an AC-operated instrument which may be used for the accurate amplitude measurement of approximately sinusoidal infrasonic waves down to 20 millivolts peak-to-peak and to .05 cps while avoiding the distracting effects of pointer flutter. If appreciable pointer movement can be tolerated a correction chart included herein may be used to extend the range down to .01 cps, but even in this case the pointer variation will be small compared to the sweep occurring when using the technique of a dc voltmeter to observe peak amplitude of very low frequency waves.

Elimination of meter flutter is made possible by the utilization of storage circuits having large time constants. This, or any other device designed to serve the same purpose, must inherently result in long decay times if not also in extended build-up periods. However, the build-up time of the Model 316 is mainly controlled by the period of the wave so that the waiting time is reduced to little more than the latter. It is in regard to the measurement of a level which has been immediately preceded by one of greater magnitude that the large decay time may conceal the existence of the lower value. To avoid such ambiguities and also to eliminate long waiting times arising from the decay period, a METER RESET push-button switch is available to the operator for the purpose of rapidly discharging the storage circuits prior to making a fresh measurement.

In order to allow the voltmeter to be used in the audio-frequency range without requiring the use of the reset button for rapid stabilization of reading, an extreme position is provided on the function switch of the voltmeter for use of the latter above 10 cps. However, the position for frequencies above 0.05 cps may be used also at audio-frequencies without error provided the reset feature is properly utilized as described herein.

The single, easily read, logarithmic voltage scale of the meter, covers a range of 2-20, has the well-known feature of retaining a constant accuracy at any point, and is accompanied by a linear decibel scale covering a range of 0-20 db. Four decade ranges on the main control knob permit voltage measurements to be made from 20 millivolts to 200 volts peak-to-peak. The RMS voltage of a sine wave applied to the input of the voltmeter would be obtained on dividing the readings by the factor 2.828, i.e. on this basis the range of the voltmeter is 7.07 millivolts to 70.7 volts RMS of a sine wave.

An overall accuracy of ±3% at any voltage between the limits 0.02 volts and 200 volts peak-to-peak and for any frequency in the range 0.05 to 30,000 cps is supported by substantial inverse feed-back in the amplifier system of the voltmeter, thus counteracting the effect of varying line voltage, tube deterioration and changes in circuit elements. Considerable care has been taken to render negligible those drift effects which plague many types of dc amplifiers and which could also cause spurious indications in the voltmeter, for even though it is not responsive to a steady dc component, the voltmeter will indicate the presence of a slowly varying, non-periodic, signal owing to its very low frequency response.

2. SPECIFICATIONS

BALLANTINE MODEL 316

INFRASONIC PEAK TO PEAK ELECTRONIC VOLTMETER

Voltage Range

20 millivolts to 200 volts Peak-to-Peak in four decade ranges. (Not responsive to constant d.c. component of applied signal)

Accuracy

3% over entire range
No change in reading for line voltage range 100-130 volts

Frequency Range

Accuracy maintained in range .05 cps-30 kc. Correction chart supplied for measurements in range 0.01 to 0.05 cps. Square waves measured with stated accuracy down to 0.5 cps.

Input Impedance

10 megohms, shunted by approx. 40 uuf on .2 volt range and by approx. 30 uuf on all other ranges when function switch is set to MEAS >0.05 cps HI-DAMP. When set to MEAS >10 cps LO-DAMP - shunt capacities are 10 uuf less.

Scales

Logarithmic voltage scale (illuminated) reading from 2 to 20. Linear decibel scale reading from 0-20 db.

Power Supply

105-125 volts, 60 cps, 45 watts

Tube Complement

One each of 5693, 6136, 6AU6, 6AL5, 5814, 0B2, 6X4 and two 0A2

Dimensions

Portable box construction - 6-7/8 inches wide, 7-1/2 inches high, 12-3/8 inches long

Weight

14 lbs.

3. OPERATION

The Model 316 is supplied with tubes and is ready to operate as received. Connect the power cord to a source of 105-125 volts, 60 cycles only, switch to STABILIZE FOR D.C. COMPT. Illumination of the meter will indicate that the power is on.

Allow in general a warm-up period of 20 minutes before commencing measurements. Advantage should be taken of the fast decay condition available with the function switch set to MEAS>10 cps - LO DAMP if measurements are to be made only in the audio range for which switch position the warm-up time can be reduced to 5 minutes.

The very low frequency response of this voltmeter requires that the user must contend with a waiting period for a stabilized meter indication when the function switch is set to MEAS > 0.05 CPS - HI DAMP. Hence at frequencies below 1 cps the meter response time is 1 to 2 periods, while above 1 cps the response time ranges from 1 to 5 seconds depending on the scale reading.

3.1 AC Voltage Measurement

Set the range selector knob to the voltage range desired. Depress the RESET button before taking a reading.

If the order of the voltage to be measured is not known, commence with the range selector on the highest range and turn it successively through the lower range until a deflection is noted. Depress the METER RESET button before taking a reading.

A slight degree of meter flutter (up to 3%) will be observed at or near the lowest normal operating frequency of 0.05 cps. Under these conditions the best accuracy is realized if the highest reading noted throughout the cycle is recorded. This precaution is especially necessary when measuring in the range 0.01-0.05 cps where it will be necessary to multiply all readings by a correction factor as determined from the graph included at the end of this handbook.

3.1.1 Use of RESET Feature

Two distinct uses of the METER RESET button are to be recognized -

(a) When taking a reading which is lower than that observed immediately preceding it the METER RESET button should be held down from 3 to 4 seconds to allow the pointer to fall completely to the lower deflection.

(b) Following a severe overload in the MEAS>10 CPS - LO DAMP position exceeding 10 times the full scale voltage of the range being used. The METER RESET button should be depressed from 3 to 5 seconds following such a shock in order to permit the amplifier to restabilize.

3.1.2 Overload in MEAS>0.05 CPS - HI DAMP Position

Following a severe overload on the 20 and 200 volts Full Scale ranges the voltmeter should be restabilized by returning the function switch to STABILIZE FOR OVERLOAD until the pointer has reached the left-hand stop.

For overloads exceeding ten times full scale deflection voltage on the two most sensitive ranges or for momentary open-circuiting at the input when using these ranges, the voltmeter should be restabilized by setting the function switch to STABILIZE FOR DC COMP until the pointer has reached the left-hand stop.

These operations are effective for the MEAS>10 CPS - LO DAMP position also, but the method of 3.1.1(b) will be found more convenient. Inadequate stabilization may result in pointer creep occurring during subsequent measurements even though the voltage being measured is quite constant.

3.2 Maximum Input Levels

The amplifier circuits are designed to saturate promptly when the voltage exceeds the full scale indication of the meter thus protecting it from mechanical damage, however, heavy overloading causes a disturbance to the amplifier which requires time for recovery (see previous section).

The maximum amplitude of the alternating voltage may not exceed 500 volts peak-to-peak on the 20 and 200 volt ranges, whereas an overload factor of 100 is permitted on the 0.2 and 2 volt ranges.

3.3 Presence of DC Component In Input Signal

The DC component of the input signal should not exceed the voltages given in Table I. If higher DC voltages are encountered it is recommended that an external capacitor be connected in series with the high potential input terminal of the voltmeter. This external capacitor should be of low-leakage plastic film type having a VDC rating as high as the value of the DC component, and having a value of 20 microfarads if frequencies down to 0.05 cps are being applied to the voltmeter.

Care is necessary to avoid overloading on the 0.2 and 2 volt ranges arising from the step function representing the sudden application, change, or removal of the DC component combined with the AC input signal. Thus the function switch should be set to STABILIZE FOR DC COMPT, either just prior to the application, or during the change, of the DC component and should be held there for the period stated in Table I in order to allow the input blocking capacitor of the voltmeter to reach full charge. If a dc component is applied while the function switch is set to some other position, the charging period will take about 5 minutes.

Care is necessary to avoid overloading on the 0.2 and 2 volt ranges arising from the step function response during the sudden application, change, or removal of the DC component combined with the AC input signal. Either the function switch should be set to STABILIZE FOR DC COMPT. either just prior to the application, or during the change, of the DC component and should be held there for the period stated in Table 1 in order to allow the input blocking capacitor of the voltmeter to reach full charge. If the DC component is applied with the function switch in set to some other position, the charging period will take about 5 minutes.

TABLE I

Range - VOLTS FULL SCALE	0.2v	2v	20v	200v
Max Direct Voltage	20v	100v	200v	200v
Minimum Time STABILIZE FOR DC COMPT	60 sec	60 sec	10 sec	7 sec

Set to STABILIZE FOR DC COMPT during the discharge of the blocking capacitor after the DC component has been removed. Unless the resistance of the source is less than 100K a resistor of not greater than this value should be connected across the input to accelerate the discharge.

NOTE When set to STABILIZE FOR DC COMP the input resistance of the instrument is decreased from 10 megohms to 220,000 ohms in order to allow the input blocking capacitor to reach full charge in a short time. On the two most sensitive ranges dielectric absorption (soakage) of the input capacitor will make the necessary stabilization time longer. Lower values for maximum DC voltage were given in Table I so as to keep the stabilization time below 60 sec. Higher DC voltages may be applied up to 200 volts but on these ranges then the necessary stabilization time will be extended. Any spurious reading caused by residual absorption effects will be nullified on depressing the METER RESET button.

3.4 Scale Range Adjustment

No zero setting control as in conventional indicating instruments applies to the logarithmic meter fitted to the Model 316. This adjustment is replaced by an operation, herein designated scale range adjustment, to insure that a voltage which produces a full scale reading of 20 on the VOLTS scale will produce a reading of 2 when it is attenuated in the ratio of 10 to 1. Ordinarily no such adjustment should be necessary except at very infrequent intervals, but if a deviation from the above-mentioned condition is noted an adjustment accurate to approximately 1% may be made as follows while adhering to the sequence of steps as written.

3.4.1 Scale Range Adjustment

Allow the voltmeter to warm up for at least 20 minutes. Connect to the input a stable AC source of about 2 volts, peak to peak, of less than 1% distortion, and of any convenient frequency in the range 100 to 1000 cps. Set function switch to MEAS>10 CPS - LO DAMP. Adjust the amplitude so that the meter reads precisely full scale (20) on the 2 volt range. Switch to the 20 volt range. The meter should now read 2. If not, the SCALE ADJ control should be rotated until it does. Switch back to the 2 volt range to see whether the meter still reads 20. If not, readjust the amplitude for full scale reading and repeat the above procedure. Do not disturb the CAL ADJ control except as stated in 3.5 below.

3.5 Calibration Adjustment

Normally, no attention need be given to the question of calibration as the large amount of feedback in the instrument gives it sufficient inherent stability to maintain the original factory calibration within the accuracy specified. However, to correct errors which might result from the cumulative effects of wide variations in characteristics of replacement tubes from average tubes, a variable control has been provided which allows the calibration to be shifted a small amount. This control is located at the right-hand side of the meter and marked ADJ CAL.

In adjusting the calibration of the instrument the source voltage should be a pure sinusoidal wave of any convenient frequency from 100 to 1000 cps and the external rms indicating voltmeter used as the standard should be accurate to at least 1% at the selected test frequency. Furthermore, it is necessary to bear in mind that when comparing a peak-to-peak voltmeter with an external standard RMS meter the readings of the latter have to be multiplied by 2.828. (For convenience in testing set the function switch to MEAS>10 CPS - LO DAMP.) The Ballantine Model 420 DC-AC Precision Calibrator is ideal for the purpose since it is a source even surpassing the above requirements while also providing for direct reading of peak-to-peak voltages.

4. MEASUREMENT OF VOLTAGES BEYOND RANGE OF THE INSTRUMENT

4.1 Below 20 Millivolts Peak-to-Peak

Symmetrical waves may be measured down to 140 microvolts peak-to-peak, or to 50 microvolts RMS of a sine wave from zero frequency to 0.2 cps without corrections when using the Ballantine Model 700 Sensitive Inverter (described in the general Ballantine catalogue) in conjunction with the Model 316.

On a peak-to-peak in and out basis the effective gain of the Model 700 is 141.4 (43 db), but when dealing with sine waves the gain on a RMS basis is 400 if the reading on the combining Model 316 is taken as RMS and not peak-to-peak.

It is also possible to provide a special version of the Model 700 which will pass frequencies up to 2 cps, but before ordering the latter please apply to Ballantine Laboratories, Inc. for a quotation of price and delivery.

4.2 Above 200 Volts Peak-to-Peak

The Ballantine Model 1320 Multiplier is suitable for use with the Model 316 to extend its range by a factor of 100 to 1 so as to read from 200 to 20,000 volts peak-to-peak of symmetrical waves. When ordering please specify that the Model 1320 is to be used with the Model 316.

5. SERVICING

Servicing of this instrument by the user is not recommended except for the renewal of the fuse and tubes. The fuse is a 3 AG, 3/4 ampere, cartridge type located adjacent to the point of entry of the line cord to the chassis.

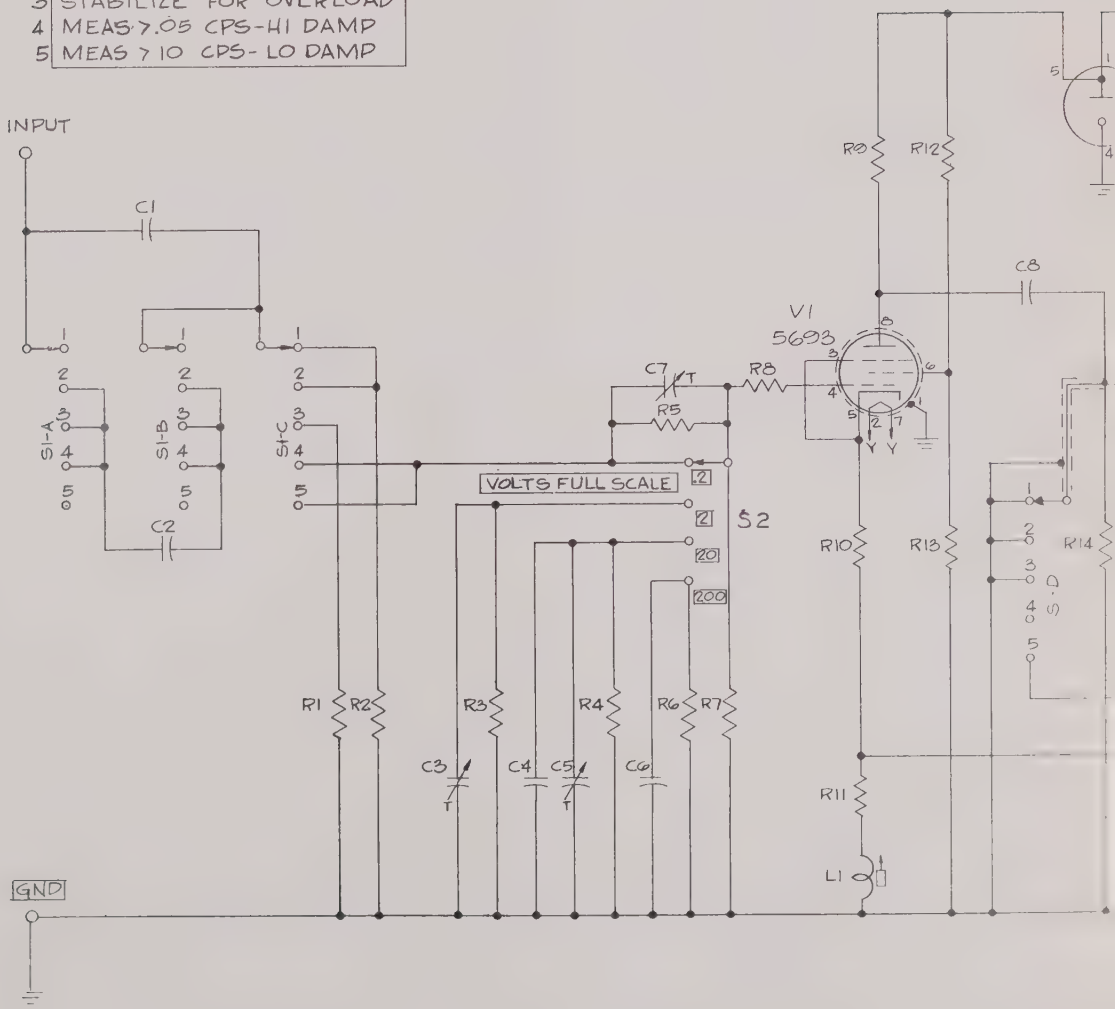
If it is ever found that replacement of the 5693 RCA Special Red Tube V1 becomes necessary, check the stabilization as described in Section 3.1.2 after installing the new tube in order to insure that it is free from high reverse grid current which causes excessive switching transients. Try another tube if the first replacement introduces this effect.

If other trouble develops, it is recommended that the instrument be returned to us for servicing. Before doing this, the trouble should be described to us by letter, after which shipping instructions will be furnished.

THE SYSTEM OF FUNCTION SWITCHING (S1-A TO S1-H) SHOWN HERE IS SYMBOLIC ONLY AND NOT A PICTORIAL REPRESENTATION OF THE ACTUAL SWITCHES.

FUNCTION SWITCH S1-A TO S1-H POSITIONS:

1	OFF
2	STABILIZE FOR DC. COMPT
3	STABILIZE FOR OVERLOAD
4	MEAS 7.05 CPS-HI DAMP
5	MEAS 7 10 CPS- LO DAMP



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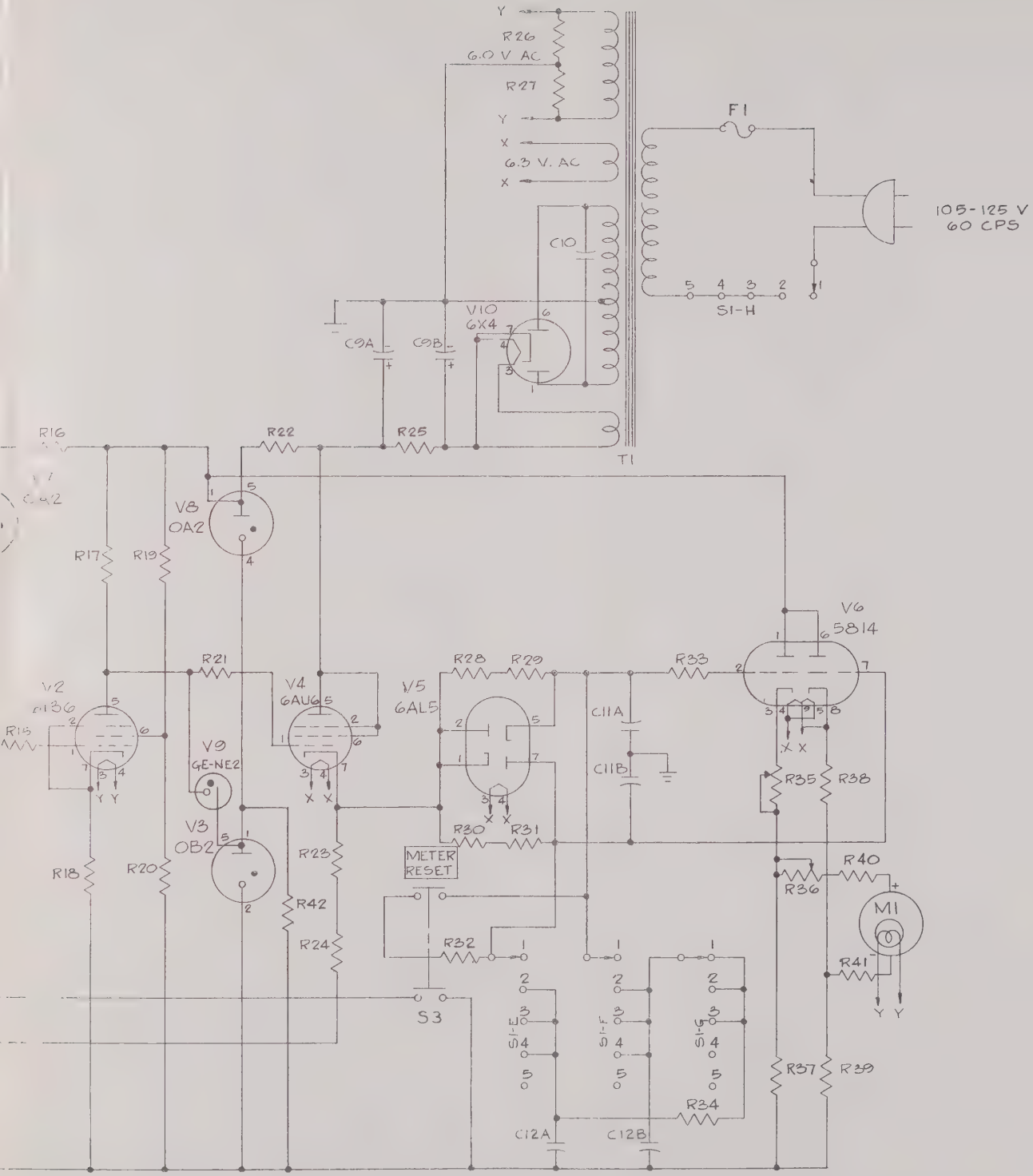

NOTE:
SCALE RANGE ADJUSTMENT R35
CALIBRATION ADJUSTMENT R36

C VOLTMETER
EL 316
MC-452 E

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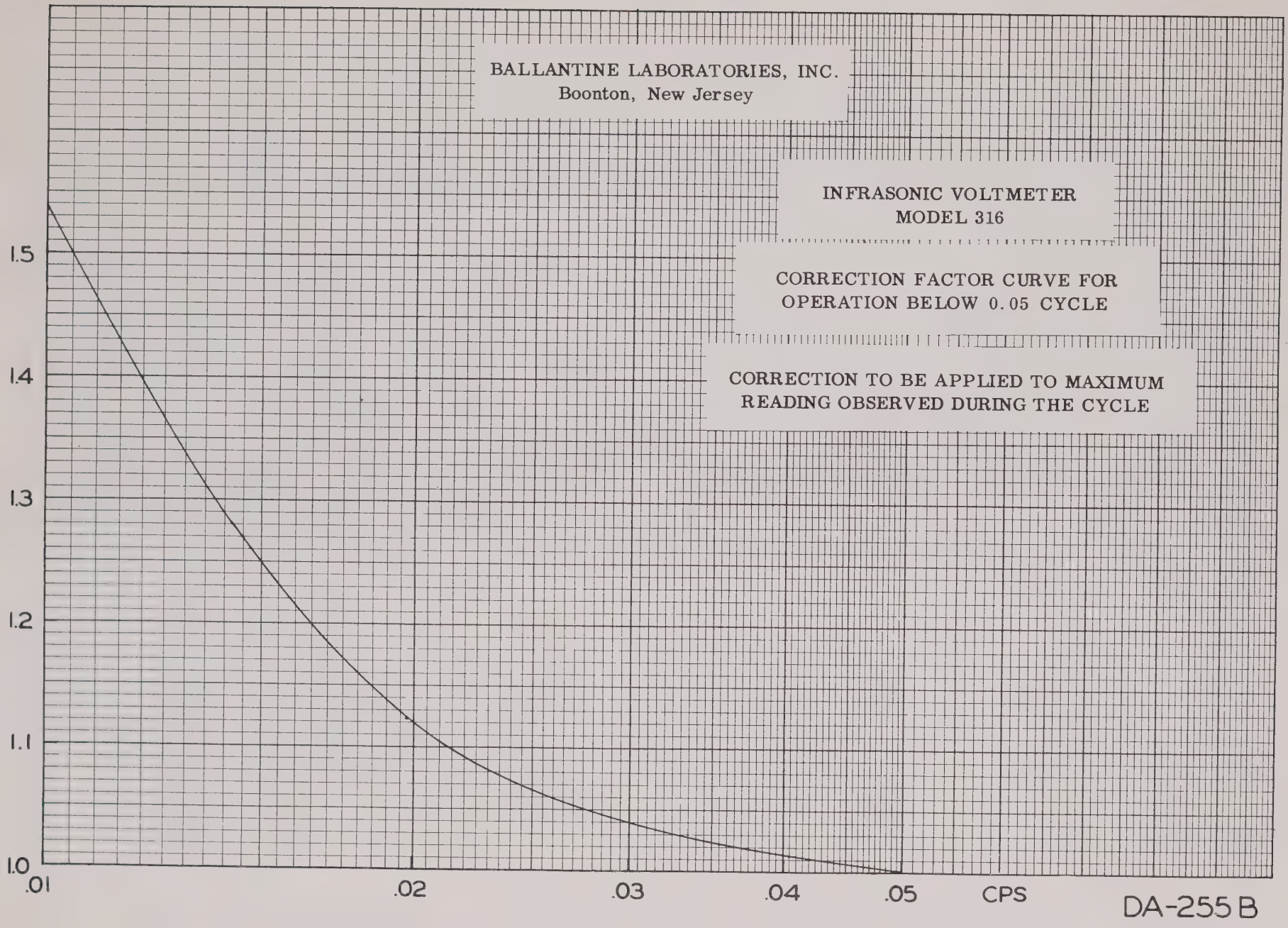
BALLANTINE LABORATORIES, INC.
Boonton, New Jersey
INFRASONIC VOLTMETER
MODEL 316
CORRECTION FACTOR CURVE FOR
OPERATION BELOW 0.05 CYCLE
CORRECTION TO BE APPLIED TO MAXIMUM
READING OBSERVED DURING THE CYCLE
1.5
1.4
1.3
1.2
1.1
1.0
.01
.02
.03
.04
.05
CPS
DA-255 B

REPLACEMENT PARTS LIST

REFER TO MODEL 316 SCHEMATIC DIAGRAM, ISSUE MC452E

B. L. Part #	Circuit Symbol	RESISTORS	Manufacturer
1001	R1	10 megohms, Type EB, 10%,	Allen-Bradley
1022	R2	220,000 ohms, Type EB 10%,	Allen-Bradley
1469	R3	1,250,000 ohms, Type CP-1, 1%.	Wilkor
1391	R4	102,000 ohms, Type CP-1/2, 1%,	Wilkor
1475	R5	10 megohms, Type C-177AN,	Mepco
1324	R6	10,000 ohms, Type CP-1/2, 1%,	Wilkor
1463	R7	10 megohms, Type CP-1, 1%,	Wilkor
1032	R8	47,000 ohms, Type EB, 5%,	Allen-Bradley
1303	R9	250,000 ohms, Type CP-1/2, 1%,	Wilkor
1334	R10	2,200 ohms, Type CP-1/2, 1%,	Wilkor
1758	R11	71 ohms, Type Special, 1%,	Ballantine
1313	R12	47,000 ohms, Type CP-1/2, 1%	Wilkor
1041	R13	18,000 ohms, Type EB 5%,	Allen-Bradley
1007	R14	2 megohms, Type EB, 5%	Allen-Bradley
1057	R15	1,000 ohms, Type EB, 5%	Allen-Bradley
1704	R16	10,000 ohms, Type 151E, 5%,	Sprague
1390	R17	400,000 ohms, Type CP-1/2, 1%,	Wilkor
1330	R18	3,000 ohms, Type CP-1/2, 1%,	Wilkor
1029	R19	56,000 ohms, Type EB, 5%,	Allen-Bradley
1039	R20	22,000 ohms, Type EB, 5%,	Allen-Bradley
1064	R21	220 ohms, Type EB, 5%,	Allen-Bradley
1713	R22	2,000 ohms, Type 5KT, 5%,	Sprague
1459	R23	15,000 ohms, Type CP-1, 1%,	Wilkor
1459	R24	15,000 ohms, Type CP-1, 1%,	Wilkor
1210	R25	390 ohms, Type HB, 5%,	Allen-Bradley
1057	R26	1,000 ohms, Type EB, 5%,	Allen-Bradley
1057	R27	1,000 ohms, Type EB, 5%,	Allen-Bradley
1000	R28	22 megohms, Type EB, 10%,	Allen-Bradley
1001	R29	10 megohms, Type EB, 10%,	Allen-Bradley
1000	R30	22 megohms, Type EB, 10%,	Allen-Bradley
1001	R31	10 megohms, Type EB, 10%,	Allen-Bradley
1022	R32	220,000 ohms, Type EB, 10%,	Allen-Bradley
1038	R33	27,000 ohms, Type EB, 10%,	Allen-Bradley
1017	R34	390,000 ohms, Type EB, 5%,	Allen-Bradley
1914	R35	1,000 ohms, Type Q Potentiometer,	I.R.C.
1913	R36	30,000 ohms, Type Q Potentiometer,	I.R.C.
1209	R37	30,000 ohms, Type HB, 5%,	Allen-Bradley
1064	R38	220 ohms, Type EB, 5%,	Allen-Bradley
1209	R39	30,000 ohms, Type HB, 5%,	Allen-Bradley
1316	R40	40,000 ohms, Type CP-1/2, 1%,	Wilkor
1313	R41	47,000 ohms, Type CP-1/2, 1%,	Wilkor
1015	R42	470,000 ohms, Type EB, 5%,	Allen-Bradley

REPLACEMENT PARTS LIST

REFER TO MODEL 316 SCHEMATIC DIAGRAM, ISSUE MC452E

B. L. Part #	Circuit Symbol	CONDENSERS	Manufacturer
2166	C1	.1 uf, 200 volt, Type 615G,	Good-All
2165	C2	2 uf, 200 volt, Type 615G,	Good-All
2431	C3	3-12 uuf, Type TS2A-3,	Erie
2237	C4	160 uuf, Type CM-15,	El-Menco
2429	C5	7-45 uuf, Type TS2A-7,	Erie
2231	C6	2,000 uuf, Type CM-20,	El-Menco
2457	C7	.7-3 uuf, Type 535-OR7,	Erie
2165	C8	2 uf, 200 volt, Type 615-G,	Good-All
2032	C9A/B	60/20 uf, Type DFP 450/450 VDCW,	Sprague
	C10	0.8 uf, 660 VACW,	Part of #3044
2171	C11A/B	.068/.068 uf, 200 volt, Type 90693,	Sprague
2167	C12A/B	10/10 uf, 200 volt,	Gudeman
		OTHER COMPONENTS	
3005	L1	Peaking Coil,	Meissner
3044	T1	Power Transformer,	Ballantine
3406	F1	3/4 amp. fuse, Type 3AG,	Littelfuse
3167	M1	Indicating Meter,	Ballantine
3243	S1-A to S1-H	Function Switch,	Ballantine
3240	S2	Volts Full Scale Switch,	Ballantine
3238	S3	Meter Reset Switch,	Ballantine
		TUBES	
3125	V1	Type 5693 (Red),	RCA
3134	V2	Type 6136,	General Electric
3128	V3	Type 0B2,	RCA or GE
3109	V4	Type 6AU6,	RCA or GE
3108	V5	Type 6AL5,	RCA or GE
3133	V6	Type 5814A,	General Electric
3106	V7, V8	Type 0A2,	RCA or GE
3138	V9	Type GE-NE2,	General Electric
3105	V10	Type 6X4,	RCA or GE

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